Courses content of the semester 1 at URCA

Course title: Disciplinary reinforcement in chemistry, biology, process engineering

Key words	Fundamentals, general chemistry, organic chemistry, chemical bond, electronegativity, thermodynamics, equilibria, oxido-reduction, acids and bases. Nomenclature, stereochemistry, electronic effects, reactions in organic chemistry. Biochemistry, microbiology, enzymology, process engineering, vegetal biochemistry, molecular biology Material and energetic balance, reactors and ideal flows Notion of unit operation, of transfer, kinetics and equilibrium.
Aims	This course is dedicated for biology and chemistry students and aims to give them basic knowledge in chemistry or biology as well as in process engineering.
Content	**Lectures** - Disciplinary reinforcement in chemistry: General chemistry: chemical bonding, electronegativity, thermodynamics (change of state, mixtures), chemical equilibria, oxido-reduction, acids and bases Organic chemistry: nomenclature, stereochemistry, electronic effects, organic functions and reactions or Plant biochemistry (composition and structure of plant molecules) Microbiology (eukaryotic / prokaryotic cells, bases of microbial metabolism), molecular biology (genome and its expression) Enzymology (enzymes of plant and microbial origins, bases in enzymology) - Disciplinary reinforcement in process engineering: Material and energy balances Reactors and ideal flows Unitary operation concept Notions of transfer, kinetics and equilibrium **Tutorial class** Step by step explanation of basic chemistry exercises Material and energy balances as part of a biorefinery Pre-dimensioning of bioreactors
ECTS	**3**
Skills	Knowledge and understanding For a passing grade the student must • Strengthen his (her) knowledge in the fundamentals of general and organic chemistry or the fundamentals of biochemistry, microbiology and enzymology as well as the basics of process engineering. • Acquisition of knowledge and fundamental concepts to understand agro-resource processing methods and establish

	relationships between structures and properties of intermediates and products.
Module Coordinator(s)	Marie-Charlotte Belhomme
Teaching staff	Sandrine Bouquillon, Marie-Charlotte Belhomme, Caroline Rémond, Harivony Rakotoarivonina, Julien Lemaire (Ecole Centrale Paris)
Language of instruction	English
Nb hours of lectures	25 h
Nb hours of practical work	
Nb hours of tutorials	10 h
Nb hours of personal work	15 h (preparation of tutorial)
Nb hours of other	
Length of the internship in weeks	
Bibliography recommended	Articles from the scientific literature
Prerequisites	Basic general knowledge in chemistry
Teaching period (when)	Semester 1 of the Master
Place of teaching (where)	URCA
Assessment	**Session 1**: Written exam : /100 **Session 2:** Written exam : /50 Oral presentation : /50

Course title: Physiology and genetic of plant development

Key words	Plant reproduction, seed, germination, flower and fruit development, genetic for crop selection
Aims	Gain knowledge on plant reproduction from the flower and fruit development to the seed development and germination Basis of plant development and plant reproduction genetics, their potential use in crop selection. Get a comprehensive view of the gene function involved in the regulation of plant development and reproduction; analyse scientific papers relevant to plant physiology and developmental genetics; design and analyse an experiment.
Content	**Lectures** Physiology of flowering process, pollination, fertilization and both fruit and seed maturity. Impact of internal and external factors on reproduction process. Developmental genetic in angiosperms at vegetative and reproductive level in relation to the plant physiology. Overview of epigenetic mechanisms and transcription factors involved in plant development regulation. Notions of hybridity and genetic analysis of progeny. **Tutorial class** Role of phytohormones, light and temperature from initiation of flowers to fruit maturity and on seed growth. Role of genes involved in embryogenesis and plant development.

	Role and regulation of transcription factors involved in vegetative development. Use of developmental genes in assisted-marker selection. Exercises on genetic analysis of hybrids and progeny. **Practical class** Biochemical characterization of fruit and seed maturity (sugars, acids and proteins quantification). Molecular characterization of gene involved in vegetative development (use of mutants).
ECTS	**6**
Skills	Knowledge and understanding For a passing grade the student must master the following topics: • Flower and fruit development • Seed germination and plant development • Induction of reproduction • Plant development and reproduction genetic • Use of genetic for crop selection Competences and skills For a passing grade the student must • analyse scientific papers relevant to plant physiology and developmental genetics; • design and analyse an experiment Judgement and approach For a passing grade the student must • develop a critical analyse of experimental approach (research paper and experimental design) • expose a critical view of experimental results
Module Coordinator(s)	Florence Fontaine
Teaching staff	Florence Fontaine, Sylvain Cordelier, Olivier Fernandez, Philippe Laporte
Language of instruction	English
Nb hours of lectures	22h
Nb hours of practical work	10h
Nb hours of tutorials	18h
Nb hours of personal work	100h (preparation of courses, tutorial and practical work, writing of technical report, searching and learning of course's complements in scientific literature)
Nb hours of other	
Length of the internship in weeks	**10 weeks**
Bibliography recommended	Articles from the scientific literature and books
Prerequisites	Plant physiology, molecular genetics, plant biotechnology
Teaching period (when)	Semester 1 of the Master
Place of teaching (where)	URCA
Assessment	**Session 1**: Final written exam: /60

	Written exam (tutorial courses): /20 Technical report about practical courses: /20 **Session 2:** Oral presentation: /60 Written exam (tutorial courses): /20 Technical report about practical courses: /20

Course title: Agricultural and viticultural soils

Key words	Soils, agroecosystems
Aims	Enhance the knowledge and skills on soil properties, soil functioning and soil vulnerability in agroecosystems. Understanding of the role of soils in ecosystems; understanding of physical, chemical and biological processes in soils; assessment of possible threats to soils in agroecosystems.
Content	**Lectures:** Soil formation Mineral and organic soil constituents Chemical and physical properties of soils : - Water in soils - Soil fertility Soil vulnerability in agroecosystems **Practical class:** Methods of soil analysis Case studies in agroecosystems
ECTS	**3**
Skills	Knowledge and understanding For a passing grade the student must • ……. Competences and skills For a passing grade the student must • ……. Judgement and approach For a passing grade the student must • ……
Module Coordinator(s)	Benjamin Cancès
Teaching staff	Benjamin Cancès, Marie Ponthieu, Xavier Morvan, Maxime Gommeaux, Gwenaëlle Lashermes
Language of instruction	English
Nb hours of lectures	20 h
Nb hours of practical work	5 h
Nb hours of tutorials	
Nb hours of personal work	
Nb hours of other	

Length of the internship in weeks	
Bibliography recommended	
Prerequisites	General knowledge on geology and biology
Teaching period (when)	Semester 1 of the Master
Place of teaching (where)	URCA
Assessment	**Session 1:** Final written exam: /70 Written exam: /30 **Session 2:** Final written exam: /100

Course title: Plant-soil interactions

Key words	Agrosystem, plant nutrition, soil abiotic stresses, rhizosphere
Aims	Acquire knowledges about plant-soil interactions for a sustainable agriculture. Knowledge of different soil components involved in crop production Understand and evaluate the impact of different soil factors on plant production at the agrosystem scale. Analyze and provide solutions to preserve and improve the quality of the agrosystem.
Content	**Lectures** Exploitation of the soil by plants Regulation of root system architecture by nutrients and soil stress Plant nutrition, sensing, transport and signaling Interactions between plant and symbiotic soil microorganisms Plant adaptation to soil stresses (metals, organic inputs, …) and phytoremediation **Tutorial and practical classes** Preparation and presentation of scientific projects related to topics addressed in courses with the goal of learning to develop scientific reasoning and to link new information with the acquired knowledge. Illustration of lectures by practical classes; Adaptation of plants to soil Impact of heavy metals and pesticides on plant physiology; phytoremediation
ECTS	**3**
Skills	Knowledge and understanding For a passing grade the student must understand: • the importance of root system components for nutrient acquisition and agrosystem services. • how plant physiological traits can be coupled to increase nutrient foraging by roots? • molecular mechanisms involved in altering the root system in response to local nutrient availability or to the plant's nutritional status.

	• how can plants adapt and detoxify heavy metals and chemicals in soil? • how beneficial rhizospheric microbes drive soil stability, alter plant morphology, increase mineral nutrition and detoxification? Competences and skills For a passing grade the student must • Be able to identify plant functional traits for a better nutrition and soil services • Know how to optimize nutrient availability and soil fertility • Know how to detoxify soil by stimulating phytoremediation process • Use scientific tools to address a hypothesis, apply the protocol, generate results, discuss and present them. Judgement and approach For a passing grade the student must • be able to apprehend and evaluate the impact of different soil factors on plant production • be able to analyse and provide plant-based solutions to preserve and improve the soil quality
Module Coordinator(s)	Aziz Aziz
Teaching staff	Aziz Aziz, Patricia Trotel Aziz, Jérôme Crouzet
Language of instruction	English
Nb hours of lectures	15 h
Nb hours of practical work	6 h
Nb hours of tutorials	4 h
Nb hours of personal work	50 h (preparation of tutorial, oral presentations, and practical works)
Nb hours of other	
Length of the internship in weeks	
Bibliography recommended	Recent/significant peer-reviewed scientific publications
Prerequisites	Plant physiology, Plant-microbe interaction, agronomy
Teaching period (when)	Semester 1 of the Master
Place of teaching (where)	URCA
Assessment	**Session 1:** Final written exam : /50 Oral presentation (tutorial courses) : /25 Technical report about practical courses: /25 **Session 2:** Final written exam : /50 Oral presentation : /25 Technical report about practical courses: /25

Course title: Plant components and biorefining

Key words	Starch, lipids, cellulose, hemicelluloses, pectins, lignins, fibers, proteins from plants. Biofuels, biogas, building blocks, polymers, agromaterials.
Aims	Acquire the basic knowledge about plant components (biochemistry, properties, biosynthesis) and their further use in biorefining for various applications (bioenergy, building-blocks and materials) Biochemistry and properties of plant components, general knowledge about biorefineries and bioeconomy, the state of biorefineries today : main processes and targeted products
Content	**Lectures** Composition, structure and biosynthesis of main plant components : - Carbohydrates : starch, sucrose, cellulose, hemicelluloses, pectins - Proteins - Lipids - Lignins Introduction to the biorefining: - Definition and challenges (environmental, economical, societal) - Biofuels (bioethanol and biodiesel 1G, 2G, 3G) - Biogas (methanisation) - Building blocks (Top 10, production) - Biopolymers from building blocks (examples : PLA, PET, PE , ...) - Biomaterials (composites with fibers) **Tutorial class** Based on articles studies and on practical examples : **Practical class** Extraction and transformation of plant components Visit of the biorefinery site of Pomacle-Bazancourt
ECTS	**6**
Skills	Knowledge and understanding For a passing grade the student must • Understand the concept and challenges of biorefining • Know the composition and properties of plant components • Be able to describe the main extraction processes, the main conversions routes of plant component into bioenergies, biomolecules and biomaterials • Identify and understand the bottlenecks for improving biorefining from different plant components • Know the various application sectors of products from biorefineries Competences and skills For a passing grade the student must • Be able to describe a biorefining strategy from different feedstocks and for various applications

	• Apply a scientific approach: proposal of a protocol to address a hypothesis, apply the protocol, generate results and interpret them Judgement and approach For a passing grade the student must • Be able to evaluate and describe the complexity of biorefining concept: the bottlenecks from feedstocks to final products • Have an overview of the R&D and innovations in the evolving biorefining concept
Module Coordinator(s)	Caroline Rémond
Teaching staff	Caroline Rémond, Emmanuelle Devarenne, Hervé Sartelet, Brigitte Chabbert
Language of instruction	English
Nb hours of lectures	25 h
Nb hours of practical work	17 h
Nb hours of tutorials	8 h
Nb hours of personal work	100 h (preparation of tutorial and practical work)
Nb hours of other	
Length of the internship in weeks	
Bibliography recommended	Articles from the scientific literature
Prerequisites	Biochemistry
Teaching period (when)	Semester 1 of the Master
Place of teaching (where)	URCA
Assessment	**Session 1:** Final written exam : /60 Oral presentation (tutorial courses) : /10 Technical report about practical courses: /30 **Session 2:** Final written exam : /80 Oral presentation : /5 Technical report about practical courses: /15

Course title: Molecular Biology of Microorganisms

Key words	Microorganisms (procaryotes and eucaryotes), synthetic biology and microbial engineering, omics, biomolecules and bioproductions
Aims	To acquire basic knowledge in biological systems analyses and synthetic biology to understand tomorrow's challenges in various applications (production of molecules of interest for food/feed environment, biomaterials, energy…)
Content	**Lectures** -Introduction in synthetic biology and metabolic engineering of microorganisms (and communities) for the production of molecules of interest (concept of efficient cellular factories and microbial chassis for industrial and oenological applications…) -Methodologies used to produce recombinant proteins in microbial reactors (expression systems in procaryotes and eucaryotes).

	-Omics approaches to investigate the cellular functioning and to screen functional biodiversities ((meta)genomics, transcriptomics,…) **Tutorial class** -Lecture understanding and complements - Critical analysis publications directly linked to the lessons : objectives, originality of the scientific approaches and methodologies used, analyses of results -Practical utilization of some omics pipelines -Preparation to the practical class **Practical class** Production of a target compound in modified strains of *E. coli* - Basic genetic manipulations (amplification, DNA extraction purification, digestion, ligation) for recombinant plasmid constructions -transformation of bacterial host and selection of recombinant clones -Metabolites productions and analyses -Practical class report
ECTS	**3**
Skills	Knowledge and understanding For a passing grade the student must understand the concept and challenges of new technologies , biotechnology and their impacts • Know the basis on molecular technology tools and the basis of microbial functioning (structure, genetics, physiology….) (if not acquired in previous years) Competences and skills For a passing grade the student must • Apply a scientific approach: suggest an experimental design to address an issue, apply the protocol, generate results and interpret them Judgement and approach For a passing grade the student must • Be able to evaluate and describe the complexity of molecular biology concept to address an issue
Module Coordinator(s)	Harivony Rakotoarivonina
Teaching staff	Harivony Rakotoarivonina, Ludovic Besaury , Sofiene Abdellaoui
Language of instruction	English
Nb hours of lectures	10h
Nb hours of practical work	10h
Nb hours of tutorials	5h
Nb hours of personal work	30h -preparation of tutorials and practical works - scientific literatures

	- upgrading on basic microbiology, molecular biology and the main cellular functions
Nb hours of other	20h practical reports writing
Length of the internship in weeks	
Bibliography recommended	Articles from the scientific literature : publications directly linked to the lessons and in the field of biotechnology, metabolic engineering and biology of systems
Prerequisites	Basic microbiology, molecular biology, biochemistry
Teaching period (when)	Semester 1 of the Master
Place of teaching (where)	URCA
Assessment	**Session 1:** Final written exam : /60 Written exam: /15 Technical report of practical work: /25 **Session 2**: Final written exam : /70 Technical report of practical work: /30

Course title: Green Chemistry, bio-sourced building-blocks

Key words	Valorization of biomass, green chemistry principles, green (bio)processes, bio-based compounds
Aims	Acquire knowledge on green chemistry (fundamental principles and applications for biorefineries). Acquire advanced knowledge on the potentiality of bio-based molecules for and from green chemistry.
Content	**Lectures** Principles of green chemistry: E-factor, Atom economy, Synthesis auxiliaries, Catalysis, Clean activation processes (energy saving), Unusual media (water, ionic liquids, supercritical solvents, etc.), few examples of bioc-atalysis. Organometallic catalysis (metal-catalysed cross coupling reactions, C-H functionalization, ecocatalysis). Access routes and valorization of platform molecules from renewable raw materials. **Tutorial class** Study of scientific publications and oral presentation of the main results of these publications. Work in pairs. **Practical class** Green reactions through microwaves activation or without solvent
ECTS	**3**
Skills	Knowledge and understanding For a passing grade the student must • Know and understand green chemistry principles • Know and understand major characteristics of catalyses • Be able to identify platform molecules

	• Know and understand biorefinery processes • Know the main metal-catalysed cross coupling reactions Competences and skills For a passing grade the student must be able to • Compare between oil based chemistry and bio-based chemistry • Analyse the green characters of various processes • Evaluate green chemistry factors • Be able to explain why selective metal-catalysed C-H functionalization is challenging Judgement and approach For a passing grade the student must be able to • Identify limitations of a process in terms of green chemistry and propose greener approaches • Valorize new bio based compounds
Module Coordinator(s)	Sandrine Bouquillon
Teaching staff	Sandrine Bouquillon, Marie Charlotte Belhomme
Language of instruction	English
Nb hours of lectures	12 h
Nb hours of practical work	6 h
Nb hours of tutorials	4 h
Nb hours of personal work	55 h (preparation of practical work and tutorials)
Nb hours of other	
Length of the internship in weeks	
Bibliography recommended	
Prerequisites	General knowledge of organic and general chemistry. L3 Level.
Teaching period (when)	Semester 1 of the Master
Place of teaching (where)	URCA
Assessment	**Session 1:** Final written exam : /50 Oral presentation (tutorial courses) : /30 Technical report about practical courses: /20 **Session 2:** Final written exam : /100

Course title: Green Line Project – 1st stage

Key words	Biotechnology, bioeconomy, innovation, biomolecules, biorefining, life cycle analysis, white biotechnologies, fractioning, extraction, functional properties, biological activity, chemical intermediates
Aims	• Acquire knowledge on the principal challenges of bioindustries • Acquire knowledge on legislative framework of bioindustries • Conduct scientific literature research and synthesis writing
Content	The valorisation of renewable resources, i.e. biomass in the large sense, is on the base of the bioeconomy. Biomass constitutes a source of molecules, macromolecules and supramolecular assemblies which can be used in numerous applications of virtually every industrial domain, such as food and cosmetics industry, chemical, materials and textile industries, pharmaceuticals and biomedicine. For that, strategies of deconstruction of complex biological tissues need to be employed, using mechanical, chemical, enzymatic (biotechnological) methods. To give some examples, such methods can be employed to fabricate natural antioxidants, pigments, thickening agents, surfactants, lubricants, solvents, materials, composites. White biotechnology or green chemistry can be employed to re-assemble biobased building blocks to substances or assemblies of designed function, such as polymers, fragrances, pharmaceuticals, chemicals. Different real case applications in this domain, such as the development of deconstruction strategies of a given plant for the fabrication of functional polysaccharides, the microbial and/or enzymatic production of platform molecules with valorisation of the co-products, the design of a biorefinery of microalgae, the valorisation of agricultural by-products in the cosmetics industry will be presented by an associated partner during the integration week of Bioceb. A group of 2-3 students willing to work on a given project will be formed. This group will work together during the first semester on the definition of the objectives, structure and boundaries of the project through exchanges with socio-economic bioeconomy actors, industrial actors and literature state of the art. The module consists in: • Introduction lecture on bioindustries • Lectures on demand concerning specific technological needs of a given green line project • Lecture on the legislative framework • Industrial conferences and visits on industrial sites related to the green line project • Interviews with different actors on the subject of the green line project • Tutored literature research and synthesis writing • Writing up of a literature report including state of the art based on academic literature, patents, overview of regulations, technological reports, economic reports
ECTS	**3**
Skills	Knowledge and understanding For a passing grade the student must:

	• Know principal challenges of biobased industries • Know legislative framework of bioindustries • Know structure of principal biomass constituents and their functions • Know principal methods of fractionation of biomass • Know key concepts of the biorefinery, green chemistry and white biotechnology Competences and skills For a passing grade the student must: • Collect information, verify origin and diversity, integrate rules of intellectual property, realize a bibliography • Structure information using an academic formalism Judgement and approach For a passing grade the student must: • Elaborate project presentation and report
Module Coordinator(s)	**Sandra** Domenek (AgroParisTech), **Sandrine Bouquillon** (URCA), **Aurore Richel** (ULiège), **Kontturi Eero** (Aalto), **Yevgen Karpichev** (TalTech)
Teaching staff	To be defined – depending on the project themes.
Language of instruction	English
Nb hours of lectures	9
Nb hours of practical work	
Nb hours of tutorials	15
Nb hours of personal work	39
Nb hours of other	9 (industrial conferences, visits)
Length of the internship in weeks	
Bibliography recommended	
Prerequisites	
Teaching period (when)	All along the first semester
Place of teaching (where)	
Assessment	Written report by groups assessed by the corresponding supervisors